इंटरनेट मानक

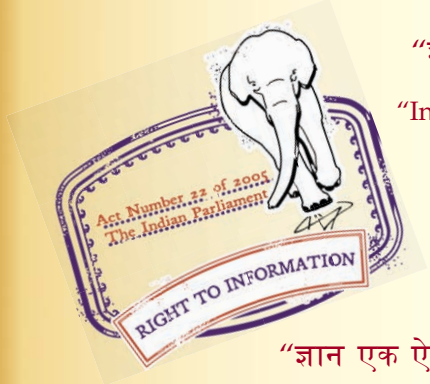
Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

"जानने का अधिकार, जीने का अधिकार"
Mazdoor Kisan Shakti Sangathan
"The Right to Information, The Right to Live"

"पुराने को छोड नये के तरफ"
Jawaharlal Nehru
"Step Out From the Old to the New"

IS 11902 (1986): Titanium and titanium alloy bars and billets [MTD 7: Light Metals and their Alloys]



"ज्ञान से एक नये भारत का निर्माण"
Satyanarayan Gangaram Pitroda
"Invent a New India Using Knowledge"

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

BLANK PAGE

IS : 11902 - 1986
(Reaffirmed 1997)

Indian Standard

SPECIFICATION FOR TITANIUM AND TITANIUM ALLOY BARS AND BILLETS

UDC 669·295—422 + 669·295·5—422

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

October 1987

Gr 3

Indian Standard

SPECIFICATION FOR TITANIUM AND TITANIUM ALLOY BARS AND BILLETS

Special Alloys Sectional Committee, SMDC 33

Chairman	*Representing*
DR P. RAMA RAO	Defence Metallurgical Research Laboratory, Hyderabad
Members	
SHRI J. NEGESH BHATT	Indian Telephone Industries Ltd, Bangalore
SHRI S. NAPAYANAN (*Alternate*)	
SHRI S. BHATTACHARYYA	Uniabox Alloy Products Ltd, Thane
SHRI A. K. MALLIK (*Alternate*)	
SHRI A. K. CHAKRABORTY	Guest Keen Williams Ltd, Howrah
SHRI S. N. SARKAR (*Alternate*)	
DR S. B. CHOUDHRY	Ministry of Defence [DTD & *P* (AIR)]
SHRI S. S. BEDI (Alternate)	
SHRI M. K. DUTTA	Steel Authority of India Ltd (Alloy Steel Plant, Durgapur)
SHRI R. C. JHA (*Alternate*)	
SHRI D. K. DUTTA	Directorate General of Ordnance Factories, Calcutta
SHRI L. B. SINGH (*Alternate*)	
SHRI B. N. HALDAR	National Metallurgical Laboratory (CSIR), Jamshedpur
SHRI G. G. NAIR (*Alternate*)	
DR D. P. LAHIRI	Defence Metallurgical Research Laboratory, Hyderabad
SHRI S. R. SAHAI (*Alternate*)	
DR M. NAGESWARA RAO	Mishra Dhatu Nigam Ltd, Hyderabad
SHRI V. K. GUPTA (*Alternate*)	
SHRI R. P. NARAIN	Hindustan Aeronautics Ltd, Koraput
SHRI R. P. NARAYAN *(Alternate)*	
DR S. G. PATIL	Electronica Commission (IPAG), New Delhi
DR R. C. TRIPATHI (*Alternate*)	
SHRI M. PRABHARARA MEHANDALE	HMT Ltd, Bangalore
SHRI A. SHANTHARAM (Alternate)	
PROF V. RAGHAVAN	Indian Institute of Technology, New Delhi
DR A. N. KUMAR (*Alternate*)	
SHRI S. RAJAGOPALAN	Arim Metal Industries Pvt Ltd, Calcutta
SHRI S. K. NANGIA (*Alternate*)	

(Continued on *page* 2)

(*Continued* from *page* 1)

Members	*Representing*
DR V. RAMACHANDRAN	National Aeronautical Laboratory, Bangalore
DR R. V. KRISHNAN (*Alternate*)	
SHRI T. RAMASUBRAMANIAN	Directorate General of Technical Development, New Delhi
DR R. P. SAHU	Indian Space Research Organization (ISRO)
SHRI M. K. SEN	Ministry of Defence (DGI)
SHRI S. K. ROY (*Alternate*)	
SHRI SISIR SEN	Steel Authority of India Ltd (Bhilai Steel Plant, Bhilai)
SHRI B. K. JALLAN (*Alternate*)	
DR R. SOMASUNDARAM	Bharat Heavy Electricala Ltd, Bhopal
SHRI R. K. SETH (*Alternate*)	
SHRI T. R. SHANMUGAM	Bharat Electronics Ltd, Bangalore
SHRI M. M. THOMARE	Bhabha Atomic Research Centre, Bombay
SHRI M. K. MALLIK (*Alternate*)	
SHRI K. RAGHAVENDRAN, Director (Struc & Met)	Director General, BIS (*Ex-officio Member*)

Secretary

SHRI B. K. MUKHOPADHYAY
Deputy Director (Metals), BIS

Panel for Titanium and Titanium Alloys for Chemical Industries, SMDC 33/P-2

Convener	
SHRI R. BALASUBRAMANYAM	Ministry of Dcfence (DMRL)
Members	
SHRI R. L. SAHA (*Alternate* to Shri R. Balasubramanyam)	
SHRI D. K. BISWAS	Naval Chemical and Metallurgical Laboratory, Bombay
SHRI M. B. DESHMUKH (*Alternate*)	
SHRI VIJAY MEHTA	Shriram Foods & Fertilizer Industries, New Delhi
SHRI S. C. SABHARWAL (*Alternate*)	
SHRI M. MOHANAN	Mishra Dhatu Nigam Ltd, Hyderabad
SHRI M. P. VORA *(Alternate)*	
DR G. J. GURU RAJA	Bharat Heavy Plate and Vessels Ltd, Visakhapatnam
SHRI K. V. G. KRISHNAMURTHY (Alternate)	
SHRI C. H. KRISHNAMURTHI RAO	Titanium Equipment and Anode Manufacturing Co Ltd, Madras
DR THANGAPPAN	Tutabuym Tabtakym Products Pvt Ltd, Madras
SHRI GEORGE THOMAS	Vikram Sarabhai Space Centre, Trivandrum

Indian Standard

SPECIFICATION FOR TITANIUM AND TITANIUM ALLOY BARS AND BILLETS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 15 October 1986, after the draft finalized by the Special Alloys Sectional Committee, had been approved by the Structural and Metals Division Council.

0.2 Titanium and its alloys possess high specific strength and excellent corrosion resistance and are being increasingly used in many chemical, aerospace and other industrial applications.

0.3 Bars and billets are **used** as material for construction or converted into components by various processing and fabrication techniques.

0.4 This standard has been prepared as a guide for the consumers of titanium bars and billets for selection of an optimum grade required for the application.

0.5 For the benefit of the purchaser, particulars to be specified while ordering for the titanium alloy bars and billets have been included in Appendix **A.**

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 The seven grades of titanium and titanium alloy bars and billets are covered by:

Grade A	Unalloyed titanium
Grade B	Unalloyed titanium
Grade C	Unalloyed titanium
Grade D	Unalloyed titanium

*Rules for rounding of numerical values (***revised).***

Grade E	Unalloyed titanium + Palladium
Grade F	Unalloyed titanium + Palladium
Grade G	Titanium alloy (6 percent aluminium + 4 percent vanadium)

2. PRODUCT CLASSIFICATION

2.1 Bars are classified as:

a) Rounds/bars	10·0 to 110 mm dia, both inclusive
b) Squares, hexagons and octagon bars	Cross-sectional area less than 10 000 mm²
c) Rectangular bars	Less than 250 mm in width and greater than 5·0 mm in thickness and cross-sectional area less than 10 000 mm².

2.2 Billets are classified as the product (round or square) having cross-sectional area greater than 10000 mm² with the width less than five times the thickness.

3. CHEMICAL COMPOSITION

3.1 The grades of titanium and titanium alloy covered by this specification shall conform to the chemical composition requirement prescribed in Table 1.

3.2 Permissible variation in product analysis shall be as given in Table 2. However, this does not broaden the specified heat analysis requirements, but cover variations between laboratories in the measurement of chemical content. The manufacturers shall not ship material that is outside the limits specified in Table 1 for the applicable grades.

4. MECHANICAL PROPERTIES

4.1 Mechanical properties of the material supplied under this specification shall conform to the requirements given in Table 3.

4.2 Tensile properties are determined on specimens machined and tested in accordance with IS :1608-1972* and IS :1825-1975†. Tensile properties shall be determined using a strain rate of 0.003 to 0·007 mm/mm/min through the specified yield strength and then increasing the rate so as to produce failure in approximately one additional minute.

*Method for tensile testing of steel products (*first revision*).

†Specification for aluminium milk cans (*first revision*).

TABLE 1 CHEMICAL COMPOSITION

(Clause 3.1)

ELEMENT, PERCENT Max	GRADE A	GRADE B	GRADE C	GRADE D	GRADE E	GRADE F	GRADE G
Nitrogen	0·03	0·03	0·05	0·05	0.03	0·03	0·05
Carbon	0·10	0·10	0·10	0·10	0·10	0.10	0·10
*Hydrogen [Bars	0·012 5	0.012 5	0.012 5	0·012 5	0·012 5	0.012 5	0·012 5
*Hydrogen [Billets	0.010	0·010	0.010	0·010	0.010	0.010	0.010
*Iron	0·20	0·30	0·30	0·50	0.20	0.30	0.40
Oxygen	0·18	0·25	0·35	0.40	0·18	0·25	0·20
Aluminium	—	—	—	—	—	—	5·5-6·75
Vanadium	—	—		—	—	—	3·5-4·5
Palladium	—	—	—	—	0·12-0·25	0·12-0·25	
Residual elements (each)†	0·1	0·1	0·1	0·1	0·1	0·1	0·1
Residual elements (total)†	0·4	0·4	0·4	0·4	0·4	0·4	0·4
Titanium‡	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder

*Lower values may be obtained by negotiation with the manufacturer.

†This need not be reported as residual elements present in metal or an alloy in small quantities are inherent to the manufacturing process but not added intentionally.

‡The percentage of titanium is determined by difference.

TABLE 2 PERMISSIBLE VARTATIONS IN PRODUCT ANALYSIS

(Clause 3.2)

ELEMENT	PRODUCT ANALYSIS, PERCENT	PERMISSIBLE VARIATION IN PRODUCT ANALYSIS, PERCENT
Nitrogen	0·05 *Max*	+ 0.005
Carbon	0·10 *Max*	+ 0.02
Hydrogen	0.02 *Max*	+ 0·002
Iron	0.50 Max	+ 0'05
Oxygen	0·30 *Max*	+ 0'03
Aluminium	4·0-6·75	± 0·40
Oxygen	0·31-0·40 *Max*	± 0.04
Vanadium	3·5-4·5	± O-15
Palladium	0·12-0·25	± 0·02
Residual elements (each)	0·1	± 0.02

TABLE 3 TENSILE REQUIREMENTS*

(*Clause* 4.1)

GRADE	TENSILE STRENGTH *Min* (MPa)	YIELD STRENGTH 0·2 PERCENT OFFSET *Min* (MPa)	ELONGATION IN 4D, *Min* PERCENT	RBDUCTION OF AREA, *Min* PERCENT
A	240	**170**	**24**	**30**
B	**345**	**275**	**20**	**30**
C	**450**	**380**	18	**30**
D	**550**	**485**	**15**	**25**
E	**240**	**170**	**24**	30
F	**345**	**275**	**20**	**25**
G	**895**	**825**	**10**	**25**

*These properties apply to longitudinal sections up to 75 mm in thickness with a maximum of 65·0 cm². Mechanical properties of larger sections shall be negotiated between the manufacturer and the purchaser.

5. SIZE, WEIGHT AND PERMISSIBLE VARIATIONS

5.1 Size — Dimensional tolerances on titanium and titanium alloy material covered by this specification shall be as specified in Tables 4 to 11 as applicable.

5.2 Weight -Different lengths of the same size and grade may be combined for extra quantities as agreed upon by the purchaser and the manufacturer., The shipping weight of any item of an ordered size in any finish shall not exceed the calculated weight by more than 10 percent of the ordered quantity. Quantity extras are applicable to individual item of a grade, thickness, width and length ordered at one time for shipment at one time to one destination.

6. SUPPLY OF MATERIAL

6.1 Annealed titanium and titanium alloy bars and billets may be supplied as descaled, sand blasted, ground or rough turned. The bars and billets shall be free of harmful external and internal defects which will adversely affect its suitability for the intended applications. The small surface defects can be removed by spot grinding provided the thickness remains within the specified tolerance limits for the thickness ordered.

7. SAMPLING

7.1 Samples for chemical analysis shall be representative of the material being tested. The utmost care must be used in sampling titanium for chemical analysis because of its great affinity for elements such as oxygen, nitrogen and hydrogen. Therefore, in cutting samples for analysis, the operation should be carried out in so far as possible in a dust-free atmosphere. Chips should be collected from clean metal and tools should be clean and sharp. Samples for analysis should be stored in suitable containers.

8. METHODS OF CHEMICAL ANALYSIS

8.1 The methods of analysis used shall be in accordance with any published standard methods such as agreed upon by the manufacturer and the purchaser.

9. REJECTION

9.1 Material not conforming to this specification or to authorized modifications shall be subject to rejection. Method of disposal of rejected material will be agreed upon by the manufacturer and the purchaser.

10. TEST REPORTS

10.1 The manufacturer shall certify that the material supplied has been inspected and tested as per this specification and supply copy of test report showing that the product meets the specified chemical, mechanical and dimensional requirements for the appropriate grade.

11. PACKING

11.1 The material purchased under this specification shall be packed for shipment either by boxing, crating, single boarding, butlapping or any other method as agreed upon by the manufacturer and the purchaser.

12. MARKING

12.1 Unless otherwise specified, a stamped metal tag shall be attached with individual pieces of bundles indicating purchase order number, the specification number, the nominal size and manufacturers heat number. If packed in box, the box shall also be marked with the same information. In addition the bars of 25·0 mm of higher diameter or thickness respectively shall be stamped with the heat number within 50 mm of one end.

12.2 The material may also be marked with Standard Mark.

NOTE — The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act 1986 and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers, may be obtained from the Bureau of Indian Standards.

TABLE 4 PERMISSIBLE VARIATIONS IN SIZE FOR TITANIUM BARS HOT ROLLED ROUNDS AND SQUARES

(*Clause* 5.1)

All dimensions are in millimctes.

SPECIFIED SIZE	SIZE VARIATIONS	OUT-OF-ROUND* OR OUT-OF-SQUARE†
6·5 and up to 8·0	± 0·13	0·20
Over 8·0 up to 11·0	± 0·15	0·23
Over 11·0 up to 15·0	± 0·18	0·25
Over 15·0 up to 22·5	± 0·20	0·30
Over 22'5 up to 25·0	± 0·23	0·33
Over 25·0 up to 27·5	± 0.25	0.38
Over 27·5 up to 30·0	± 0·28	0.40
Over 30·0 up to 35·0	± 0·30	0'45
Over 35·0 up to 37·5	± 0.35	0.53
Over 37·5 up to 50·0	± 0·40	0·58
Over 50·0 up to 65·0	+ 0·80 - 0	0·58
Over 65·0 up to 90·0	+ 1·20 - 0	0'90
Over 90·0 up to 110	+ 1·60 - 0	1.20

*Out-of-round is the difference between the maximum and the minimum diameters of the bars, measured at the same cross-section.

tout-of-square section is the difference in the two dimensions at the same cross section of square bar, each dimension being the distance between opposite faces.

TABLE 5 PERMISSIBLE VARIATIONS IN SIZE FOR TITANIUM BARS — HOT ROLLED HEXAGONS AND OCTAGONS

(*Clause* 5.1)

All dimensions in millimetres.

SPECIFIED SIZES BETWEEN OPPOSITE SIDES	SIZE VARIATION	MAXIMUM DIFFERENCE 3 MEASUREMENTS
6·5 and up to 12·5	± 0.18	0.28
Over 12·5 up to 25·0	± 0·25	0.38
Over 25.0 up to 37.5	± 0·53	0.65
Over 37·5 up to 50·0	± 0·80	0·80
Over 50·0 up to 65·0	± 1.20	1·20
Over 65·0 up to 90·0	± 1·60	1·60

TABLE 6 PERMISSIBLE TOLERANCES IN SIZE FOR TITANIUM BARS — HOT ROLLED FLATS

(*Clause* 5.1)

All dimensions in millimetres.

SPECIFIED WIDTHS	THICKNESS VARIATION FROM SPECIFIED THICKNESS			WIDTH VARIATION
	3·2 and up to 12.5	Over 12·5 up to 25.0	Over 25·0 up to 50.0	
Up to 25·0	± 0·20	± 0·25	—	± 0·4
Over 25·0 up to 50·0	± 0.30	± 0.38	± 0·80	± 0.8
Over 50·0 up to 100.0	± 0.38	± 0.50	± 0.80	+ 1·6 — 0·8
over 100 up to 150	± 0·38	± 0·50	± 0.80	+ 2·4 — 1·6
Over 150 up to 200	± 0'40	± 0'65	± 0.80	+ 3.20 — 4·0
Over 200 up to 250	± 0·53	± 0.80	± 0·80	+ 4·0 — 4·8

TABLE 7 PERMISSIBLE VARIATIONS IN SIZE FOR **TITANIUM** BARS - **COLD FINISHED ROUNDS**

(*Clause* **5.1**)

All dimensions are in millimetres.

SPECIFIED SIZE	*SIZE VARIATION
Over 12·5 to less than	± 0.05
25·0 to less than 37·5	± 0·06
37·5 and up to 100.0	± 0·08

*When it is neerssary to heat-treat or heat treat and pickle after cold finishing because of special hardness or mechanical property requirements, tolerances are commonly double those shown in this table.

TABLE 8 PERMISSIBLE VARIATIONS IN SIZE FOR TITANIUM BARS — COLD-FINISHED HEXAGONS, OCTAGONS AND SQUARES

(*Clause* 5.1)

All dimensions in millimetres.

SPECIFIED SIZE	SIZE VARIATION *
Over 12·5 up to 25·0	$^{+0}_{-0.10}$
Over 25·0 up to 50·0	$^{+0}_{-0.16}$
Over 50·0 up to 75·0	$^{+0}_{-0.20}$
Over 75	$^{+0}_{-0.25}$

*When it is necessary to heat-treat or heat-treat and pickel after cold finishing, because of special hardness or mechanical property requirements, tolerances are commonly double those shown in this table.

TABLE 9 PERMISSIBLE VARIATIONS IN SIZE FOR TITANIUM BARS — COLD FINISHED FLATS

(Clause 5.1)

All dimensions in millimetres.

SIZE WIDTH OR THICKNESS	WIDTH VARIATIONS* FROM SPECIFIED THICKNESS		THICKNESS VARIATION*
	6·50 and under	Over 6·50	
Over 10·0 up to 25·0	± 0·10	± 0·05	± 0.05
Over 25·0 up to 50·0	± 0·15	± 0·08	± 0·08
Over 50·0 up to 75·0	± 0·20	± 0.10	± 0.10
Over 75·0 up to 110·0	± 0·25	± 0·13	± 0'13

*When it is necessary to heat-treat or heat-treat and pickle after cold finishing, because of special hardness or mechanical property requirements, tolerances are commonly double those shown in this table.

TABLE 10 PERMISSIBLE VARIATIONS IN LENGTH FOR TITANIUM BARS-HOT ROLLED AND COLD-FINISHED

(*Clause* 5.1)

All dimensions in millimctres.

SPECIFIED SIZES, ALL SHAPES	LENGTH VARIATIONS, mm	
	up to 3 500	Over 3 500 up to 7 500
up to 50·0	+ 12·5 - 0	+ 20.0 - 0
Over 50·0 up to 100·0	+ 20·0 — 0	+ 25.0 - 0
over 100.0 up to 150.0	+ 25.0 - 0	+ 32·5 - 0
Over 150·0 up to 225·0	+ 32·5 - 0	+ 37·5 - 0
Over 225·0 up to 300·0	+ 37.5 - 0	+ 50.0 - 0
Machine Cut After Machine Straightening		
up to 75.0	+ 3·2 — 0	+ 4·5 — 0
Over 75·0 up to 150·0	+ 4·5 - 0	+ 6·5 - 0
Over 150'0 up to 225·0	+ 6·5 - 0	+ 8·0 - 0
Over 225·0 up to 300.0	+ 12.5 — 0	+ 12·5 — 0

TABLE 11 CAMBER FOR HOT-ROLLED AND COLD-FINISHED TITANIUM BARS FOR MACHINING

(Clause 5.1)

All dimensions in millimetres.

Camber is the greatest deviation of a side from a straight line. Measurement is taken on the concave side of the bar with a straightedge. Unless otherwise specified, hot rolled and cold-finished bars for machining purposes are furnished machine straightened to the tolerances specified in this Table.

	Tolerance
Hot rolled	3·2 mm in any 1 500 mm, but may not exceed $\frac{3{\cdot}20 \text{ mm} \times \text{No. of m in length}}{1.5}$
Cold finished	1·60 mm in any 1 503 mm, but may not exceed $\frac{1{\cdot}60 \text{ mm} \times \text{No. ofm in length}}{1{\cdot}5}$

APPENDIX A

(*Clause 0.5*)

A-l. BASIS OF PURCHASE

A-l.1 Orders for materials under this specification shall include the following information as applicable:

a) Grade number (Clause **1.1);**

b) Product limitation (Clause 2);

c) Special mechanical properties (Table 3);

d) Marking (Clause 12);

e) Finish (Clause 3);

f) Packing (Clause **11);**

g) Required test reports (Clause **10);** and

h) Disposition of rejected material (Clause 9 **).**